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CERTIFIED TRANSLATION

I, Masaaki Iwami of 3-22, Asagaya-minami 1-chome, Suginami-ku, Tokyo, Japan, am an experienced translator of the Japanese language into the English language and I hereby certify that the attached comprises an accurate translation into English of Japanese Patent Application No. 2000-224367 filed July 25, 2000.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

August 3, 2004

Date

Masaaki IWAMI

[Name of Document] Specification

[Title of the Invention] Apparatus and Method for
Decoding MPEG Picture Stream

[What is Claimed is:]

[Claim 1] An apparatus for decoding an MPEG picture
stream, comprising:

input means for inputting said MPEG picture stream
formed by an intra picture and a predictive coded
picture;

decoding means for decoding each of the pictures of
said MPEG picture stream inputted by said input means;

control means for instructing said decoding means
to start decoding;

writing means for storing a decoding result of said
decoding means in a picture memory; and
reading means for obtaining output picture data from said
picture memory;

wherein when said predictive coded picture includes
an intra slice or an intra macroblock, said decoding
means decodes said intra slice and said intra macroblock
after being instructed to start decoding by said control
means without waiting for said intra picture to be
decoded.

[Claim 2] An apparatus for decoding an MPEG picture

stream as claimed in claim 1,

wherein when a macroblock to be referred to is already decoded, said decoding means further decodes a non-intra slice and a non-intra macroblock of said predictive coded picture by using a decoding result of said macroblock to be referred to, which is stored in said picture memory, after being instructed to start decoding by said control means without waiting for said intra picture to be decoded.

[Claim 3] An apparatus for decoding an MPEG picture stream as claimed in claim 2, further including storage means for storing a position of a macroblock decoded by said decoding means,

wherein said decoding means determines whether said macroblock to be referred to is already decoded or not on the basis of a stored content of said storage means.

[Claim 4] An apparatus for decoding an MPEG picture stream as claimed in claim 3,

wherein said storage means uses said picture memory as a storage medium for storing the position of said decoded macroblock.

[Claim 5] An apparatus for decoding an MPEG picture stream as claimed in claim 1,

wherein when said MPEG picture stream inputted by

said input means is changed, and when said predictive coded picture of said changed MPEG picture stream includes an intra slice or an intra macroblock, said decoding means decodes said intra slice and said intra macroblock without waiting for said intra picture of said changed MPEG picture stream to be decoded, and said writing means overwrites said picture memory with the decoding result of said decoding means.

[Claim 6] An apparatus for decoding an MPEG picture stream as claimed in claim 5,

wherein after said MPEG picture stream is changed, when a macroblock to be referred to is already decoded, said decoding means further decodes a non-intra slice and a non-intra macroblock of said predictive coded picture by using a decoding result of said macroblock to be referred to, which is stored in said picture memory, without waiting for said intra picture of said changed MPEG picture stream to be decoded.

[Claim 7] A method for decoding an MPEG picture stream, comprising:

a step of providing an instruction to start decoding an MPEG picture stream formed by an intra picture and a predictive coded picture;

a step of decoding each of the pictures of said

MPEG picture stream after the instruction to start said decoding;

a step of storing a result of said decoding in a picture memory; and

a step of reading and thereby obtaining output picture data from said picture memory;

wherein when said predictive coded picture includes an intra slice or an intra macroblock, in the step of decoding each of the pictures of said MPEG picture stream, said intra slice and said intra macroblock are decoded after the instruction to start said decoding without waiting for said intra picture to be decoded.

[Claim 8] A method for decoding an MPEG picture stream as claimed in claim 7,

wherein when a macroblock to be referred to is already decoded, in the step of decoding each of the pictures of said MPEG picture stream, a non-intra slice and a non-intra macroblock of said predictive coded picture are decoded by using a decoding result of said macroblock to be referred to, which is stored in said picture memory, after the instruction to start said decoding without waiting for said intra picture to be decoded.

[Detailed Description of the Invention]

[0001]

[Technical Field to Which the Invention Pertains]

The present invention relates to an apparatus and a method for decoding an MPEG picture stream suitable for use in a digital broadcast receiver, for example. More particularly, the present invention relates to an apparatus and the like for decoding an MPEG picture stream that make it possible to quickly obtain output picture data by decoding, when a predictive coded picture includes an intra slice or an intra macroblock, the intra slice and the intra macroblock of the predictive coded picture after an instruction to start decoding without waiting for an intra picture to be decoded.

[0002]

[Prior Art]

As a picture stream handled in a digital broadcast receiver, there is an MPEG (Moving Picture Experts Group) picture stream. As is well known, MPEG coded data is represented by a hierarchical structure. The hierarchical structure comprises, from the top down: a sequence layer, a GOP (Group of Picture) layer, a picture layer, a slice layer, a macroblock layer, and a block layer.

[0003]

Fig. 5 shows a sequence layer and a GOP layer. The sequence layer begins with a sequence header and ends with a sequence end. The sequence layer comprises more than one GOP. The GOP layer begins with a GOP header and comprises a plurality of pictures. The first picture is always an I-picture (intra coded picture), followed by a P-picture (predictive coded picture) and a B-picture (bidirectional predictive coded picture).

[0004]

The I-picture is an intra-frame coded picture, and therefore a single picture can be combined with only the I-picture. The P-picture is an inter-frame forward-direction predictive coded picture, and transmits its difference with respect to a previous picture, as shown in Fig. 6. A decoding apparatus (decoder) adds the difference to the previous picture and thereby decodes a picture. Thus, the P-picture requires a picture to be referred to first, and the picture decoding uses the I-picture described above as the picture to be referred to and the P-picture created by referring to the I-picture.

[0005]

The B-picture is a bidirectional predictive coded picture, and transmits its difference with respect to two pictures: a temporally preceding and a temporally

succeeding picture, as shown in Fig. 7. The decoding apparatus adds the difference to the two-hold preceding and succeeding pictures, and thereby decodes a picture. Thus, the B-picture makes it possible to reduce difference data as compared with the P-picture by referring to two pictures.

[0006]

Fig. 8 shows an example of an MPEG picture stream formed by I-, P-, and B-pictures. When such an MPEG picture stream is decoded, a conventional method decodes an I-picture, then decodes P-pictures by using a decoding result of the I-picture as a reference picture, and thereafter decodes B-pictures.

[0007]

Fig. 9 shows a conventional decoding procedure. First, decoding is started at a step ST1. At a step ST2, a first picture is read from a receiving buffer, for example. At a step ST3, operations of the steps ST2 and ST3 are repeated until an I-picture is read.

[0008]

When an I-picture is read from the stream, the processing proceeds to steps ST4 and ST5 to branch according to the type of a read picture. When the read picture is an I-picture, the I-picture is decoded at a

step ST6, and then the processing proceeds to a step ST7. When the read picture is a P-picture, the P-picture is subjected to forward-direction decoding processing at a step ST8, and then the processing proceeds to the step ST7. When the read picture is a B-picture, the B-picture is subjected to bidirectional decoding processing at a step ST9, and then the processing proceeds to the step ST7.

[0009]

At the step ST7, picture data as a decoding result is outputted. At a step ST10, the next picture is read, and then the processing returns to the step ST4 to subject the read picture to decoding processing as described above according to the picture type.

[0010]

[Problems to be Solved by the Invention]

As described above, even when an instruction to start decoding an MPEG picture stream is provided, the conventional decoding apparatus cannot decode P-pictures and B-pictures until the apparatus decodes an I-picture, and therefore a method such as blanking is adopted for the intervening period. Hence, when the digital broadcast receiver selects a channel and thereby changes the MPEG picture stream, for example, picture display on a display

unit is interrupted for a moment.

[0011]

A P-picture and a B-picture may have a small intra coded block unit. An intra coding enables decoding with only the block and thus does not require a reference picture.

It is accordingly an object of the present invention to provide an apparatus and the like for decoding an MPEG picture stream that make it possible to quickly obtain output picture data.

[0012]

[Means for Solving the Problems]

According to an aspect of the present invention, there is provided an apparatus for decoding an MPEG picture stream, comprising: input means for inputting the MPEG picture stream formed by an intra picture and a predictive coded picture; decoding means for decoding each of the pictures of the MPEG picture stream inputted by the input means; control means for instructing the decoding means to start decoding; writing means for storing a decoding result of the decoding means in a picture memory; and reading means for obtaining output picture data from the picture memory; wherein when the predictive coded picture includes an intra slice or an

intra macroblock, the decoding means decodes the intra slice and the intra macroblock after being instructed to start decoding by the control means without waiting for the intra picture to be decoded. When a macroblock to be referred to is already decoded, the decoding means further decodes a non-intra slice and a non-intra macroblock of the predictive coded picture by using a decoding result of the macroblock to be referred to, which is stored in the picture memory, after being instructed to start decoding by the control means without waiting for the intra picture to be decoded.

[0013]

In addition, according to another aspect of the present invention, there is provided a method for decoding an MPEG picture stream, comprising: a step of providing an instruction to start decoding the MPEG picture stream formed by an intra picture and a predictive coded picture; a step of decoding each of the pictures of the MPEG picture stream after the instruction to start the decoding; a step of storing a decoding result in a picture memory; and a step of reading and thereby obtaining output picture data from the picture memory; wherein when the predictive coded picture includes an intra slice or an intra macroblock, in the

step of decoding the picture data, the intra slice and the intra macroblock are decoded after the instruction to start the decoding without waiting for the intra picture to be decoded. When a macroblock to be referred to is already decoded, in the step of decoding the picture data, a non-intra slice and a non-intra macroblock of the predictive coded picture are decoded by using a decoding result of the macroblock to be referred to, which is stored in the picture memory, after being instructed to start decoding by the control means without waiting for the intra picture to be decoded.

[0014]

According to the present invention, when the digital broadcast receiver selects a channel and thereby changes an MPEG picture stream, and then an instruction to start decoding is provided, for example, an intra slice and an intra macroblock of a predictive coded picture are decoded without a wait for an intra picture to be decoded. Furthermore, when a macroblock to be referred to is already decoded, a non-intra slice and a non-intra macroblock of the predictive coded picture are decoded by using a decoding result of the macroblock to be referred to, which is stored in the picture memory. Thus, when changing the channel, for example, it is

possible to quickly obtain output picture data, shorten interruption of the pictures, and check a picture of the next channel in a short time.

[0015]

The apparatus for decoding an MPEG picture stream further includes storage means for storing the position of a decoded macroblock, and determines whether the macroblock to be referred to is already decoded or not on the basis of the stored content of the storage means. Therefore, it is possible to correctly determine validity of the macroblock to be referred to and thus prevent decoding using a wrong reference picture. The picture memory, for example, is used as a storage medium. Specifically, part of a storage area for a decoding result of each macroblock is used as a flag portion, and a value unobtainable in an actual decoding result is written in the flag portion of an undecoded macroblock. Thus, by using the picture memory to store the position of a decoded macroblock, it is not necessary to provide a dedicated storage medium or storage area.

[0016]

Furthermore, when the digital broadcast receiver selects a channel and thereby changes the MPEG picture stream, decoding results of decoded slices and

macroblocks are sequentially written over existing results without initializing the picture memory. Thus, a picture of a channel before the channel change is smoothly switched to a picture of a channel after the channel change without interruption of the pictures, and therefore picture muting and the like are not required.

[0017]

[Mode for Carrying out the Invention]

An embodiment of the present invention will now be described with reference to the drawings.

Fig. 1 shows configuration of a digital broadcast receiver 100 according to an embodiment of the present invention.

[0018]

The receiver 100 has a CPU (Central Processing Unit) 101 serving as a controller for controlling its overall operation. The CPU 101 is connected with a ROM (Read Only Memory) 102 that stores data and programs necessary for operation of the CPU 101; a RAM (Random Access Memory) 103 that stores data generated in association with control of the CPU 101 as well as supplementary data and the like obtained from an MPEG2 transport stream TS, as described later, and is used as a working area; an operating unit 104 having a plurality of

operating keys and the like; and a display unit 105 formed by a liquid crystal display device or the like for displaying status of the receiver 100 and the like.

[0019]

The receiver 100 has an antenna 106 for receiving digital broadcast signals; and a tuner 107 for selecting a broadcast signal of a specified RF channel from the digital broadcast signals of a plurality of RF channels received by the antenna 106 and then outputting digital modulated data corresponding to the broadcast signal of the specified RF channel. Channel selecting operation of the tuner 107 is controlled by the CPU 101 according to operation of the operating unit 104 by the user.

[0020]

Also, the receiver 100 has a demodulator 108 for subjecting the digital modulated data outputted from the tuner 107 to demodulation processing; and an ECC (Error Correction Code) decoder 109 for subjecting output data of the demodulator 108 to error correction processing and then providing an MPEG2 (Moving Picture Experts Group 2) transport stream TS corresponding to the broadcast signal of the specified RF channel described above. The transport stream TS is formed by a sequence of MPEG2 TS packets. The tuner 107, the demodulator 108, and the ECC

decoder 109 form a front end 110.

[0021]

In addition, the receiver 100 has a descrambler 111 for descrambling packets of scrambled video data and audio data forming the transport stream TS outputted from the ECC decoder 109; and a demultiplexer 112 for separating packets of video data and audio data of a program number (channel) specified by operation of the operating unit 104 by the user from the transport stream TS outputted from the descrambler 111 to output a video data stream VDS and an audio data stream ADS formed by the packets and for separating a packet of supplementary data of the program number (channel) to output a supplementary data stream SDS formed by the packet. The supplementary data stream SDS is supplied to the CPU 101.

[0022]

Furthermore, the receiver 100 has a video decoder 113 for subjecting the video data stream VDS outputted from the demultiplexer 112 to data expansion processing to thereby provide output video data VD; an output terminal 114 for outputting the video data VD; an audio decoder 115 for subjecting the audio data stream ADS outputted from the demultiplexer 112 to data expansion processing to thereby provide output audio data AD; and

an output terminal 116 for outputting the audio data AD.

[0023]

The receiver 100 also has an IC card interface unit 118 to which an IC card 117 is connected. The IC card interface unit 118 is connected to the CPU 101. The IC card 117 stores scramble key information and also has a function of determining whether viewing is possible or not on the basis of limited reception information sent from the CPU 101 via the IC card interface unit 118 and sending the scramble key information to the CPU 101 via the IC card interface unit 118 when viewing is possible.

[0024]

Operation of the digital broadcast receiver 100 shown in Fig. 1 will be described.

The digital broadcast signals of a plurality of RF channels received by the antenna 106 are supplied to the tuner 107. The tuner 107 selects a broadcast signal of a specified RF channel and then outputs digital modulated data corresponding to the broadcast signal. Then, the demodulator 108 subjects the digital modulated data to demodulation processing, and the ECC decoder 109 subjects output data of the demodulator 108 to error correction processing, whereby an MPEG2 transport stream TS is obtained.

[0025]

The transport stream TS is supplied to the demultiplexer 112 via the descrambler 111. The demultiplexer 112 separates packets of video data and audio data of a program number (channel) specified by operation by the user to provide a video data stream VDS and an audio data stream ADS formed by the packets.

[0026]

The demultiplexer 112 also separates a packet of supplementary data of the program number (channel) from the transport stream TS to provide a supplementary data stream SDS formed by the packet. The supplementary data stream SDS is supplied to the CPU 101, and limited reception information extracted from the supplementary data stream SDS is supplied to the IC card 117 via the IC card interface unit 118.

[0027]

The IC card 117 determines whether viewing is possible or not on the basis of the limited reception information. When viewing is possible, the IC card 117 sends scramble key information to the CPU 101 via the IC card interface unit 118. The CPU 101 sets the key information in the descrambler 111. Thus, the descrambler 111 descrambles packets of scrambled video data and audio

data, and hence the demultiplexer 112 provides the video data stream VDS and the audio data stream ADS of descrambled data.

[0028]

The video decoder 113 subjects the video data stream VDS outputted from the demultiplexer 112 to data expansion processing to thereby generate output video data VD, and the video data VD is outputted to the output terminal 114. The audio decoder 115 subjects the audio data stream ADS outputted from the demultiplexer 112 to data expansion processing to thereby generate output audio data AD, and the audio data AD is outputted to the output terminal 116.

[0029]

Details of the video decoder 113 will next be described. Fig. 2 shows configuration of the video decoder 113.

The video decoder 113 has an input terminal 150 for inputting the video data stream VDS as an MPEG picture stream; a receiving buffer 151 for temporarily storing the video data stream VDS inputted to the input terminal 150; and a variable-length decoding circuit 152 for subjecting the video data stream VDS read from the receiving buffer 151 to variable-length decoding

processing and then providing quantized DCT (discrete cosine transform) coefficient data and information of a motion vector and prediction mode. Incidentally, the receiving buffer 151 is provided to supply a fixed data continuously to the decoding circuit 152.

[0030]

The video decoder 113 also has an inverse quantization circuit 153 for subjecting the quantized DCT coefficient data obtained by the decoding circuit 152 to inverse quantization processing to thereby provide DCT coefficient data; an inverse DCT circuit 154 for subjecting the DCT coefficient data obtained by the inverse quantization circuit 153 to inverse DCT processing to thereby provide arithmetic data; a picture memory 155 for storing a result of decoding of each picture; and an output terminal 156 for outputting video data VD read from the picture memory 155.

[0031]

The video decoder 113 also has a motion compensation circuit 157 for subjecting video data stored in the picture memory 155 to motion compensation based on the motion vector information obtained by the foregoing variable-length decoding circuit 152, and then generating reference video data corresponding to the prediction

mode; and an adder 158 for adding the reference video data generated by the motion compensation circuit 157 to arithmetic data of non-intra macroblocks of a P-picture and a B-picture obtained by the inverse DCT circuit 154 to thereby provide video data as a decoding result.

[0032]

Operation of the video decoder 113 shown in Fig. 2 will be described. The video data stream VDS inputted to the input terminal 150 is temporarily stored in the receiving buffer 151. Then, the video data stream VDS read from the receiving buffer 151 is supplied to the variable-length decoding circuit 152 to be subjected to variable-length decoding processing, whereby quantized DCT coefficient data and information of a motion vector and prediction mode are obtained. The thus obtained information of a motion vector and prediction mode is supplied to the motion compensation circuit 157.

[0033]

The quantized DCT coefficient data obtained by the decoding circuit 152 is supplied to the inverse quantization circuit 153. The inverse quantization circuit 153 subjects the quantized DCT coefficient data to inverse quantization to thereby provide DCT coefficient data. The DCT coefficient data obtained by

the inverse quantization circuit 153 is then supplied to the inverse DCT circuit 154. The inverse DCT circuit 154 subjects the DCT coefficient data to inverse DCT processing to thereby provide arithmetic data.

[0034]

Consideration will now be given to a case where the inverse DCT circuit 154 outputs arithmetic data of a macroblock of an I-picture. In this case, the arithmetic data outputted by the inverse DCT circuit 154 is video data as a decoding result as it is. Thus, the arithmetic data is inputted to the picture memory 155 via the adder 158, and then written into an area corresponding to the macroblock.

[0035]

Consideration will next be given to a case where the inverse DCT circuit 154 outputs arithmetic data of a macroblock of a P-picture. When the macroblock is an intra macroblock, the arithmetic data outputted by the inverse DCT circuit 154 is video data as a decoding result as it is. Thus, the arithmetic data is inputted to the picture memory 155 via the adder 158, and then written into an area corresponding to the macroblock. On the other hand, when the macroblock is a non-intra macroblock, reference video data corresponding to

forward-direction prediction mode generated by the motion compensation circuit 157 is added to the arithmetic data outputted by the inverse DCT circuit 154, whereby video data as a decoding result is obtained. The video data is inputted to the picture memory 155, and then written into an area corresponding to the macroblock.

[0036]

Consideration will next be given to a case where the inverse DCT circuit 154 outputs arithmetic data of a macroblock of a B-picture. When the macroblock is an intra macroblock, the arithmetic data outputted by the inverse DCT circuit 154 is video data as a decoding result as it is. Thus, the arithmetic data is inputted to the picture memory 155 via the adder 158, and then written into an area corresponding to the macroblock. On the other hand, when the macroblock is a non-intra macroblock, reference video data corresponding to bidirectional prediction mode generated by the motion compensation circuit 157 is added to the arithmetic data outputted by the inverse DCT circuit 154, whereby video data as a decoding result is obtained. The video data is inputted to the picture memory 155, and then written into an area corresponding to the macroblock.

[0037]

Then, output video data VD is read from the picture memory 155 in which the decoding result is written as described above, and the video data VD is outputted to the output terminal 156.

[0038]

Fig. 3 illustrates decoding procedure of the video decoder 113. For example, when the digital broadcast receiver 100 selects a channel and hence changes the video data stream VDS as an MPEG picture stream, and then the CPU 101 provides an instruction to start decoding, decoding is started at a step ST11, and at a step ST12, a first picture is read from the receiving buffer 151 and supplied to the variable-length decoding circuit 152.

[0039]

At a step ST13, whether the read picture is an I-picture or not is determined. At a step ST14, whether the read picture is a P-picture or not is determined. When the read picture is an I-picture, the I-picture is decoded at a step ST15, and then the processing proceeds to a step ST16.

[0040]

When the read picture is a P-picture, an intra slice and an intra macroblock within the P-picture are decoded at a step ST17, and the position of a decoded

macroblock is stored at a step ST18.

[0041]

In the present embodiment, the picture memory 155 is used as a storage medium for storing the position of the decoded macroblock. Specifically, part of a storage area for a decoding result of each macroblock in the picture memory 155 is used as a flag portion, and a value unobtainable in an actual decoding result is written in the flag portion of an undecoded macroblock. In this case, the position of a decoded macroblock is stored only by writing its decoding result into the picture memory 155.

[0042]

At the next step ST19, when it is determined on the basis of the stored position of a decoded macroblock that a macroblock to be referred to is already decoded, a non-intra macroblock is subjected to forward-direction decoding processing using the decoding result of the decoded macroblock, and thereafter the processing proceeds to a step ST16.

[0043]

When the read picture is a B-picture, an intra slice and an intra macroblock within the B-picture are decoded at a step ST20, and at a step ST21, as in the step ST18 described above, the position of a decoded

macroblock is stored. At a step ST22, when it is determined on the basis of the stored position of a decoded macroblock that a macroblock to be referred to is already decoded, a non-intra macroblock is subjected to bidirectional decoding processing using the decoding result of the decoded macroblock, and thereafter the processing proceeds to the step ST16.

[0044]

At the step ST16, video data VD as a decoding result is read from the picture memory 155 and then outputted. At a step ST23, whether the decoding of one GOP is ended or not is determined. When the decoding of one GOP is not ended, the processing returns to the step ST12 to repeat the same operations as described above. On the other hand, when the decoding of one GOP is ended, the processing proceeds to steps ST24 and ST25 to branch according to the type of a read picture. When the read picture is an I-picture, the I-picture is decoded at a step ST26, and then the processing proceeds to a step ST27. When the read picture is a P-picture, the P-picture is subjected to forward-direction decoding processing at a step ST28, and then the processing proceeds to the step ST27. When the read picture is a B-picture, the B-picture is subjected to bidirectional decoding processing at a

step ST29, and then the processing proceeds to the step ST27.

[0045]

At the step ST27, video data VD as a decoding result is read from the picture memory 155 and then outputted. At a step ST30, the next picture is read from the receiving buffer 151, and then the processing returns to the step ST24 to subject the read picture to decoding processing as described above according to the picture type.

[0046]

The video decoder 113 shown in Fig. 2 performs decoding by the above-described decoding procedure illustrated in Fig. 3. Specifically, when an instruction to start decoding is provided, an intra slice and an intra macroblock of a predictive coded picture such as a P-picture or a B-picture are decoded without a wait for an I-picture to be decoded. Furthermore, when a macroblock to be referred to is already decoded, a non-intra slice and a non-intra macroblock of the predictive coded picture are decoded. Therefore, when changing the channel, for example, it is possible to quickly obtain video data VD as output picture data, shorten an interruption of the pictures, and check a picture of the

next channel in a short time.

[0047]

Fig. 4 schematically shows operation of the present embodiment when decoding is started at a midpoint of a GOP. Fig. 4 illustrates a case in which P-pictures and B-pictures are each formed by eight macroblocks, and the P-pictures and the B-pictures include intra macroblocks. In this case, the intra macroblocks of the P-pictures and the B-pictures are decoded without a wait for an I-picture of the next GOP to be decoded, and therefore a whole picture is reconstructed quickly.

[0048]

As described above, according to the present embodiment, when the digital broadcast receiver 100 selects a channel and hence changes the video data stream VDS, and then an instruction to start decoding is provided, for example, an intra slice and an intra macroblock of a P-picture or a B-picture as a predictive coded picture are decoded without a wait for an I-picture to be decoded. Furthermore, when a macroblock to be referred to is already decoded, a non-intra slice and a non-intra macroblock of the predictive coded picture are decoded by using a decoding result of the macroblock to be referred to, which is stored in the picture memory 155.

Thus, when changing the channel, for example, it is possible to quickly obtain output picture data, shorten interruption of the pictures, and check a picture of the next channel in a short time.

[0049]

Also, the present embodiment stores the position of a decoded macroblock and determines whether a macroblock to be referred to is already decoded or not on the basis of the stored content. Therefore, it is possible to correctly determine validity of the macroblock to be referred to and thus prevent decoding using a wrong reference picture.

[0050]

In addition, the present embodiment uses the picture memory 155 as a storage medium for storing the position of a decoded macroblock. Therefore, it is not necessary to provide a dedicated storage medium or storage area and thus the storage medium can be formed inexpensively.

[0051]

Though not described above, when the digital broadcast receiver 100 selects a channel and thereby changes the video data stream VDS, decoding results of decoded slices and macroblocks are sequentially written

over existing results without initializing the picture memory 155. Thus, a picture of a channel before the channel change is smoothly switched to a picture of a channel after the channel change without interruption of the pictures, and therefore picture muting and the like are not required.

[0052]

It is to be noted that while in the foregoing embodiment, the present invention is applied to a digital broadcast receiver, the present invention is of course similarly applicable to other apparatus required to decode an MPEG picture stream.

[0053]

[Effect of the Invention]

According to the present invention, when a predictive coded picture includes an intra slice or an intra macroblock, the intra slice or the intra macroblock of the predictive coded picture is decoded after an instruction to start decoding without a wait for an intra picture to be decoded. Therefore, it is possible to quickly obtain output picture data. For example, it is possible to check a picture of the next channel in a short time when changing the channel of the digital broadcast receiver.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a block diagram showing configuration of a digital broadcast receiver according to an embodiment of the present invention.

[Fig. 2]

Fig. 2 is a block diagram showing configuration of a video decoder in the digital broadcast receiver.

[Fig. 3]

Fig. 3 is a flowchart illustrating decoding procedure of the video decoder.

[Fig. 4]

Fig. 4 illustrates a method of decoding P- and B-pictures including intra macroblocks.

[Fig. 5]

Fig. 5 shows a sequence layer and a GOP layer of MPEG coded data.

[Fig. 6]

Fig. 6 shows an arrangement of MPEG I- and P-pictures.

[Fig. 7]

Fig. 7 shows an arrangement of MPEG I-, P-, and B-pictures.

[Fig. 8]

Fig. 8 illustrates an arrangement of MPEG I-, P-, and B-pictures and a conventional decoding method.

[Fig. 9]

Fig. 9 is a flowchart illustrating a conventional decoding procedure.

[Reference Numerals]

100 ... Digital broadcast receiver; 101 ... CPU; 106 ... Antenna; 107 ... Tuner; 108 ... Demodulator; 109 ... ECC decoder; 110 ... Front end; 111 ... Descrambler; 112 ... Demultiplexer; 113 ... Video decoder; 115 ... Audio decoder; 114, 116 ... Output terminals; 150 ... Input terminal; 151 ... Receiving buffer; 152 ... Variable-length decoding circuit; 153 ... Inverse quantization circuit; 154 ... Inverse DCT circuit; 155 ... Picture memory; 156 ... Output terminal; 157 ... Motion compensation circuit; 158 ... Adder

[Name of Document] Drawing

Fig. 1

100: Digital broadcast receiver

104: Operating unit

105: Display unit

107: Tuner

108: Demodulator

109: ECC decoder

111: Descrambler

112: Demultiplexer

113: Video decoder

115: Audio decoder

117: IC card

118: IC card I/F unit

Fig. 2

113: Video decoder

151: Receiving buffer

152: Variable-length decoding circuit

153: Inverse quantization circuit

154: Inverse DCT circuit

155: Picture memory

157: Motion compensation circuit

Fig. 3

Decoding procedure

ST11: Start

ST12: Read picture

ST13: Is read picture I-picture?

ST14: Is read picture P-picture?

ST15: Decode I-picture

ST16: Output decoding result

ST17: Decode intra slice and intra macroblock

ST18: Store position of decoded block

ST19: When reference macroblock is already decoded,
subject non-intra macroblock to forward-direction
decoding

ST20: Decode intra slice and intra macroblock

ST21: Store position of decoded block

ST22: When reference macroblock is already decoded,
subject non-intra macroblock to bidirectional decoding

ST23: Is decoding of one GOP ended?

ST24: Is read picture I-picture?

ST25: Is read picture P-picture?

ST26: Decode I-picture

ST27: Output decoding result

ST28: Subject P-picture to forward-direction decoding

ST29: Subject B-picture to bidirectional decoding

ST30: Read next picture

Fig. 4

Method of decoding P- and B-pictures including intra
macroblocks

Start decoding

Intra-picture code

Output picture

Partially reconstructed

Reconstructed whole picture

Fig. 5

Sequence layer and GOP layer of MPEG coded data

Sequence layer

Sequence header

Sequence end

GOP layer

GOP header

Fig. 6

Arrangement of MPEG I- and P-pictures

Time

Fig. 7

Arrangement of MPEG I-, P-, and B-pictures

Time

Fig. 8

Arrangement of MPEG I-, P-, and B-pictures and
conventional decoding method

Stream, Period of no picture display, Picture display possible from here on

Output picture

Start decoding

Fig. 9

Conventional decoding procedure

ST1: Start

ST2: Read picture

ST3: Is read picture I-picture?

ST4: Is read picture I-picture?

ST5: Is read picture P-picture?

ST6: Decode I-picture

ST7: Output decoding result

ST8: Subject P-picture to forward-direction decoding

ST9: Subject B-picture to bidirectional decoding

ST10: Read next picture

[Name of Document] Abstract

[Abstract]

[Object] To obtain output picture data quickly.

[Solving Means] For example, when a digital broadcast receiver selects a channel and thereby changes an MPEG picture stream, a video decoder starts decoding operation in response to an instruction to start decoding (ST11). When a predictive coded picture (P-picture, B-picture) includes an intra slice and an intra macroblock, the video decoder decodes the intra slice and the intra macroblock of the predictive coded picture without waiting for an intra picture to be decoded (ST17, ST21). When a macroblock to be referred to is already decoded, the video decoder further decodes a non-intra slice and a non-intra macroblock of the predictive coded picture by using a decoding result of the macroblock to be referred to (ST19, ST22). Thus, when changing the channel, for example, it is possible to quickly obtain output picture data, shorten interruption of the pictures, and check a picture of the next channel in a short time.

[Selected Drawing] Fig. 3